Lochsa River Subbasin Stream Temperature Natural Conditions Assessment

FINAL

Idaho Department of Environmental Quality, Lewiston Regional Office

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(Fish Creek, a tributary to the Lochsa River, June 2021)

Acknowledgements

This natural conditions assessment was a collaborative effort by Idaho Department of Environmental Quality (DEQ), and US Environmental Protection Agency Region 10 staff. DEQ staff included Jason Williams, Sujata Connell, Robert Esquivel, and Graham Freeman. EPA region 10 staff included Miranda Magdangal, Peter Leinenbach, and Lisa Kusnierz. All DEQ and EPA staff contributed to assessment framework design. Peter Leinenbach conducted stream shade modeling, roads, and forest harvest GIS analyses. Jason Williams analyzed temperature data and wrote the report. US Forest Service staff James (Andy) Efta, Christopher Savage, and Cameron Thomas provided helpful feedback on draft versions of the assessment. Members of DEQ's Clearwater Basin Advisory Group provided input on a draft version of the framework during an October 21, 2021 public meeting.

Executive Summary

This document describes methods the Idaho Department of Environmental Quality (DEQ) used to identify Lochsa subbasin streams where temperature impairs Cold Water Aquatic Life (CWAL) and Salmonid Spawning (SS) beneficial uses for Idaho's 2022 Integrated Report (IR) and associated results. Idaho Water Quality Standards state temperatures must not exceed numeric criteria values "due to human activities" (IDAPA 58.01.02.250.02, IDAPA 58.01.02.250.02f). Therefore, when temperatures exceed the applicable numeric criteria values, the Idaho Water Quality Standards require DEQ to determine if human activities likely cause the exceedance before concluding temperature impairs beneficial uses. To determine whether human activities likely cause criteria value exceedances, DEQ evaluates whether "natural background conditions," as defined at IDAPA 58.01.02.10.63, are present.

In the Lochsa subbassin, one or more applicable numeric temperature criteria for protection are exceeded in all 162 stream segments where temperature data were available, including all segments with data in the Selway-Bitteroot Wilderness. This pattern suggests numeric temperature criteria values may be exceeded due to natural background conditions in at least some stream segments, and a detailed natural conditions assessment is warranted. In collaboration with US Environmental Protection Agency Region 10, DEQ developed a framework for evaluating if numeric temperature criteria value exceedances in the Lochsa subbasin are likely caused by human activities.

The framework included two components. First, the framework evaluated multiple lines of evidence at the subwatershed (HUC12) spatial scale, including stream temperature data, stream riparian shade modeling, road density, modeled sediment delivery from roads, subwatershed forest harvest extent, subwatershed percent wilderness area, and the presence of grazing allotments, mine or mine prospect sites, and water diversions. The framework classified each of 45 subwatersheds in the subbasin as either (1) achieving applicable numeric temperature criteria (0 subwatersheds) (2) exceeding applicable numeric temperature criteria values, likely due to human activities (20 subwatersheds), (3) exceeding applicable numeric temperature criteria values, likely due to natural background conditions (23 subwatersheds), or (4) not assessed for temperature due to insufficient information (2 subwatersheds).

Second, subwatershed classifications were used to help assess if temperature impairs CWAL and or SS use at the assessment unit (AU) spatial scale for all 120 stream AUs in the subbasin. The Integrated Report requires DEQ to assess and report beneficial use support at the assessment unit (AU) scale, and multiple AUs fall within each subwatershed. For AUs within subwatersheds classified as exceeding applicable numeric criteria values likely due to human activities, CWAL and SS beneficial uses were assessed as not supporting due to temperature. For AUs within subwatersheds classified as natural for temperature, associated subwatershed classifications were combined with additional AU-scale lines of evidence to assess if CWAL and SS beneficial uses are supported, consistent with IDAPA 58.01.02.054.04. For AUs in these subwatersheds, CWAL and SS were classified as fully supporting only if a) biological monitoring data were available within the AU and indicated beneficial use support, or b) no biological monitoring data were available, but the AU met Integrated Report Category 1 criteria. If no biological data were available within the AU and the AU did not meet Category 1 criteria, CWAL and SS were classified as not assessed.

Sixty-three of 120 AUs (53%), including all 6 AUs comprising the Lochsa main stem and 57 tributary AUs were classified as not supporting CWAL and SS use due to temperature. Of these, the 6 main stem

AUs and 53 tributary AUs were placed on Idaho's 303(d) list for temperature, and 4 had an existing temperature TMDL (DEQ 2012) and were placed in IR category 4a. Twenty-three AUs (19%) were classified as fully supporting CWAL and SS. Thirty-four AUs (28%) had CWAL and SS classified as not assessed. Of these, 32 fell within subwatersheds with temperatures classified as natural, but CWAL and SS were classified as not assessed because AU did not have biological data available and did not meet Category 1 criteria. Two tributary AUs (ID17060303CL001_01, ID17060303CL061_02) were previously categorized as impaired by temperature with an approved TMDL (IR Category 4a) in Idaho's 2018/2020 IR, but temperature was delisted as a cause of impairment for the 2022 IR based on framework outcomes. A table with temperature impairment outcomes for all 120 stream AUs is included in supplemental materials.

For subwatersheds classified as exceeding applicable temperature criteria values likely due to natural background conditions, framework outcomes were consistent with available biological monitoring data. Biological monitoring indicated CWAL beneficial use was supported in all subwatershed classified as natural for temperature. Fisheries data also indicated salmonid spawning is widespread throughout the subbasin and occurs in subwatersheds classified as natural for temperature. Subwatershed outcomes were also consistent with an independent assessment of potential for restoration efforts to improve salmonid habitat developed by fisheries biologists (the Lochsa Atlas Restoration Prioritization Framework funded by Bonneville Power Administration) and with the US Forest Service's independent assessment of subwatershed conditions based on the USFS Watershed Condition Framework.

This assessment framework is specific to temperature and to the Lochsa subbasin. It is not applicable to other parameters or subbasins without modification and justification. EPA will review and approve or disapprove DEQ's application of this framework in Idaho's 2022 Integrated Report by issuing a decision on Idaho's 2022 Clean Water Act 303(d) list.

Acronyms and Abbreviations

AU	Assessment Unit
BSR	Biological significant reach
BT	Bull Trout
ºC	Degrees Celsius
CFR	Code of Federal Regulations
COMID	Unique stream segment ID in the National Hydrography Dataset version 2
CWA	Clean Water Act
CWAL	Cold Water Aquatic Life beneficial use
DEQ	Idaho Department of Environmental Quality
DU	Decision unit
EPA	US Environmental Protection Agency
GIS	Geographic Information Systems
GRAIP-Lite	Geomorphic Road Analysis and Inventory Package Lite Model
HUC	Hydrologic Unit Code
IDAPA	Idaho Administrative Procedure Act (citation of Idaho administrative rules)
IDFG	Idaho Department of Fish and Game
IPDES	Idaho Pollution Discharge Elimination System
LANDFIRE	Landscape Fire and Resource Management Planning Tools Program
MWMT	Maximum Weekly Maximum Temperature
NHDPlus v2	National Hydrography Dataset version 2
NorWeST	Northwest Stream Temperature database
PIBO	PacFish/InFish Biological Monitoring Program
PNV	Potential Natural Vegetation
SS	Salmonid spawning beneficial use
TMDL	Total Maximum Daily Load

USFS	US Forest Service
WCF	USFS Watershed Condition Framework
WQS	Idaho Water Quality Standards (IDAPA 58.01.02)

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Supplemental Materials

Supplemental materials referenced within this document are listed below and publicly available online through an Open Science Framework page: https://osf.io/2vunm/?view_only=775f650dd1b44555b29fa6e2f5ed4ed0

S1 2005 Lochsa Natural Conditions Assessment

S2 Stream Temperature Data

- S2.1 Stream temperature database
- S2.2 Stream temperature analysis methods and results summary
- S2.3 R tool for batch temperature analyses
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S3 Biological Data Summary

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1.0 Introduction

Under the Clean Water Act (CWA), states and tribes adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the CWA's purposes, including, wherever attainable, protecting fish, shellfish, and wildlife while providing for recreation in and on the nation's waters. Water quality standards define the beneficial uses of water that must be protected and set water quality criteria necessary to protect those uses. When a state adopts a new or revised water quality standard, the EPA must review and approve the standard before it becomes effective for CWA purposes.

The Idaho Water Quality Standards (WQS) define Cold Water Aquatic Life (CWAL) and Salmonid Spawning (SS) as two beneficial uses of water that must be protected in Idaho waters (IDAPA 58.01.02). Idaho has EPA-approved numeric temperature criteria to protect theses uses (IDAPA 58.01.02.250.02), and federal temperature criteria for Bull Trout currently apply to certain waters in Idaho. These temperature criteria are presented below in Table 1. Idaho's *Water Body Assessment Guidance 3rd edition* (IDEQ 2016) provides guidance on how to apply these and other criteria when assessing beneficial use support.

Table 1. Numeric temperature criteria applicable to the Lochsa subbasin.

Criteria	Criteria Value(s)	Where Criteria Value(s) Apply	When Criteria Value(s) Apply
Cold Water Aquatic Life (IDAPA 58.01.02.250.02.b)	22 °C daily maximum	all Idaho waters [a]	Year-round
	19 °C daily average	all Idaho waters [a]	Year-round
Salmonid Spawning (IDAPA 58.01.02.250.02.f.ii)	13 °C daily maximum	waters where SS is a designated or existing use [b]	during spawning and incubation periods for salmonids present
	9 °C daily average	waters where SS is a designated or existing use [b]	during spawning and incubation periods for salmonids present
ID Bull Trout [c, d] (IDAPA 58.01.02.250.02g and g.i)	13 °C 7-day average of daily maxima (MWMT)	waters in Idaho's 1996 bull trout conservation plan [e]	June-August (rearing period)
	9 °C daily average	waters in Idaho's 1996 bull trout conservation plan [e]	September-October (spawning period)
Federal Bull Trout [d] 40 CFR § 131.33	10 °C 7-day average of daily maxima (MWMT)	waters specified in 40 CFR § 131.33(a)(2)	June-September

[a] as defined in Idaho Code 39-3602(34), except those where CWAL is not designated but seasonal cold, warm water, or modified aquatic life uses are designated in IDAPA 58.01.02.110-160; all Idaho waters that lack aquatic life use designations receive CWAL presumed use protection (IDAPA 58.01.02.101.01). In the Lochsa, CWAL criteria apply to all streams.

[b]IDAPA 58.01.02.110 to.160 identify the designated uses of Idaho waters; existing uses are those attained on or after November 28, 1975, per IDAPA 58.01.02.10.38.

[c]ID Bull Trout and Federal Bull Trout criteria apply to CWAL beneficial use

[d]for waters where both ID and federal bull trout criteria apply, DEQ tests for exceedances using both criteria, and DEQ considers exceedance of either criteria to be a water quality standards violation

[e] waters > 600 m elevation north of the Salmon River Basin/Clearwater River Basin Divide, and waters > 1400 meters elevation south of the Salmon River Basin/Clearwater River Basin Divide in key watersheds listed in Table 6, Appendix F of Governor Batt's Idaho Bull Trout Conservation Plan: https://species.idaho.gov/wp-content/uploads/2016/05/bulltroutconservationplan-96.pdf

The WQS provide that temperatures must not exceed criteria values in Table 1 “due to human activities” (IDAPA 58.01.02.250.02, IDAPA 58.01.02.250.02f). To determine whether human activities cause criteria value exceedances, Idaho Department of Environmental Quality (DEQ) evaluates whether “natural background conditions,” as defined in IDAPA 58.01.02.10.63, are present:

> The physical, chemical, biological, or radiological conditions existing in a water body without human sources of pollution within the watershed. Natural disturbances including, but not limited to, wildfire, geologic disturbance, diseased vegetation, or flow extremes that affect the physical, chemical, and biological integrity of the water are part of natural background conditions. Natural background conditions should be described and evaluated taking into account this inherent variability with time and place.

Therefore, temperature impairs beneficial uses only when temperatures exceed criteria values due to human activities in the watershed (i.e., natural background conditions are not present).

In addition, WQS implementation provision IDAPA 58.01.02.054.04 provides that when natural background conditions exceed applicable criteria values, such exceedances alone do not violate water quality standards or impair beneficial uses. Rather, additional evidence suggesting beneficial use impairment is required to conclude a water body is impaired:

> There is no impairment of beneficial uses or violation of water quality standards where natural background conditions exceed any applicable water quality criteria as determined by the Department, and such natural background conditions shall not, alone, be the basis for placing a water body on the list of water quality limited water bodies described in Section 055.

Therefore, if Table 1 criteria values are exceeded, but natural background conditions are present and no other evidence supports a finding of impairment, the criteria value exceedance alone would not be a basis for classifying the water body as impaired. This document evaluates if and where temperatures are consistent with WQS natural background provisions in the Lochsa subbasin (Figure 1).

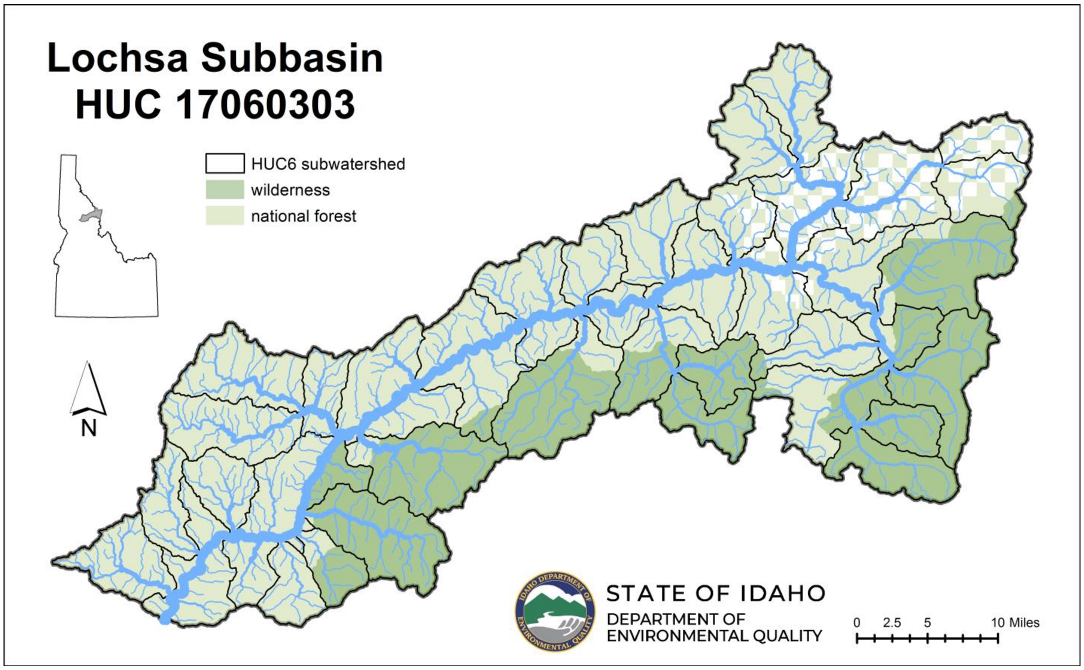

Figure 1. Lochsa River subbasin and HUC6 (12-digit HUC) subwatersheds.

2.0 Lochsa Subbasin

The Lochsa River subbasin (HUC 17060303) is in Idaho County within north central Idaho (Figure 1). The subbasin spans 1,180 square miles, from the Bitteroot Mountains along the Idaho/Montana border at the east to the Middle Fork Clearwater River at the west. Elevations range from over 8,600 feet above sea level along the Bitteroot Divide to 1,400 feet above sea level at the Lochsa River mouth. Over 90% of subbasin land area is managed by the US Forest Service, either as part of the Nez Perce-Clearwater National Forest, or the Selway Bitteroot Wilderness Area. The main stem Lochsa River begins where the Crooked Fork, Colt Killed Creek, and Walton Creek converge near Powell, ID, and flows west 67.5 miles west to its mouth at Lowell, Idaho, where the Lochsa and Selway rivers converge and become the Middle Fork Clearwater River. Most of the Lochsa River is designated as a Wild and Scenic River, and about half of the subbasin south of the Lochsa River is part of the Selway Bitteroot Wilderness Area (DEQ 1999). The subbasin contains critical habitat for Endangered Species Act-listed Snake River summer steelhead and Columbia River Bull Trout (Tetra Tech 2018). Steelhead, Bull Trout, and spring Chinook populations are classified as "present-depressed" by the Clearwater Basin Subbasin Assessment (NPCC 2003; Tetra Tech 2018). Subbasin characteristics are described in more detail elsewhere (DEQ 1999, Tetra Tech 2018).

Multiple lines of evidence suggest a Lochsa subbasin stream temperature natural conditions assessment is needed. Stream temperatures exceed salmonid spawning criteria values (Table 1) at all stream segments with data in the Selway Bitteroot Wilderness (discussed below and in Supplemental Materials S2). Yet, biological monitoring indicates aquatic life use is supported and salmonid spawning is widespread (discussed below and in Supplemental Materials S3). Further, independent assessments concluded there is low potential to improve fish habitat by decreasing temperatures in some subwatersheds (Tetra Tech, 2018), some Lochsa streams are cold water refugia for salmonids capable of providing suitable temperature conditions under future climate change (Isaak et al. 2015), and that many subwatersheds have "high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition" (USFS 2011, USFS 2021).

In 2005, DEQ and the US Environmental Protection Agency (EPA) conducted a natural conditions assessment for the Lochsa subbasin (Leinenbach 2005, Supplemental Materials S1). EPA used geographic information systems (GIS) analyses and a weight of evidence approach to identify subwatersheds within the Lochsa subbasin that meet land use qualifications for natural conditions in *Concepts and Recommendations for Using the 'Natural Conditions' Provisions of the Idaho Water Quality Standards* (Mebane & Essig 2003). The assessment evaluated harvested land area, streamside harvest miles, anthropogenic landslides, road miles, road stream crossings, and road density, and identified 16 subwatersheds that meet the definition of "natural background conditions" (IDAPA 58.01.02.10.63). In Idaho's 2012 Integrated Report, DEQ proposed to delist temperature as a cause of impairment for eight streams on Idaho's 2010 §303(d) list because they were within areas the 2005 assessment identified as meeting natural background conditions. EPA approved Idaho's 2012 Integrated Report, and thereby approved these temperature delistings based on implementation of Idaho's natural background provisions.

DEQ subsequently developed (DEQ 2012) and EPA approved (EPA 2018, 2020) temperature total maximum daily loads (TMDLs) for six AUs where DEQ determined temperatures violated applicable criteria. The temperature TMDLs define stream percent shade cover targets associated with natural channel width and system potential vegetation, defined as "the mature vegetated landscape that was present before European settlement, which includes some level of natural age-class diversity and disturbance history" (Shumar and de Varona 2009). The TMDL assumes that if shade is greater than or equal to shade associated with system potential vegetation, and there are no point sources or any other anthropogenic sources of heat in the watershed, then WQS natural background conditions (IDAPA 58.01.02.10.63) are met and temperature criteria are not violated, despite exceedance of temperature criteria values (DEQ 2012). In such cases, the TMDL required "no lowering of water quality from natural background conditions" per IDAPA 58.01.02.210.09 (DEQ 2012). The six AUs with TMDLs were included in this assessment.

Since the natural conditions assessment and the TMDL, new information pertinent to a temperature natural conditions assessment has become available, including updated geospatial datasets documenting current landscape conditions, additional stream temperature and biological monitoring data, and several relevant independent assessments (Tetra Tech 2018, USFS 2011, Isaak et al. 2015, Isaak et al. 2017, USFS 2021). This evaluation builds on previous efforts (DEQ 1999, HDR 2002. BSU-ESPPRI 2005, DEQ 2012), and uses the most current available information.

3.0 Objectives

The objective of the natural conditions assessment was to assess whether temperature impairs CWAL and or SS beneficial uses for all 120 stream AUs in the Lochsa subbasin. This objective was achieved by developing an assessment framework with two components. First, all 45 subwatersheds in the Lochsa subbasin were classified as either:

- Achieving applicable Idaho numeric temperature criteria.
- Exceeding applicable temperature criteria values likely due to human activities.

- Exceeding applicable temperature criteria values likely due to natural background conditions
- Not assessed for temperature due to insufficient information.

Second, subwatershed classifications were used to help assess support of CWAL and SS beneficial uses at the AU scale. For AUs within subwatersheds classified as temperature-impaired, CWAL and SS beneficial uses were assessed as not supporting due to temperature. For AUs within subwatersheds classified as natural for temperature, additional biological and landscape lines of evidence available within the AU were evaluated to assess whether temperature impairs CWAL and or SS beneficial uses. Methods for subwatershed scale classifications and AU-scale temperature-impairment calls are described in detail below in section 4.0.

This assessment updates and replaces the 2005 Lochsa natural conditions assessment (Leinenbach 2005, Supplemental Materials S1). In contrast to the 2005 assessment, this assessment includes an analysis of stream temperature data, uses Geomorphic Road Analysis and Inventory Package Lite Model (GRAIP-Lite) modeling to estimate sediment delivery from roads, and includes an explicit analysis of anthropogenic stream shade loss rather than inferring shade lost based on riparian harvest records.

4.0 Assessment Framework

Figure 2 documents the first framework component – methods for assigning each subwatershed into one of the 4 categories described above. Sixth field hydrologic unit code (HUC12, 12-digit HUC) subwatersheds were used, except in cases where the main stem Lochsa River bisected a HUC12. These HUC12 subwatersheds were further subdivided into north and south segments to create hydrologically complete drainage networks. The Lochsa subbasin includes 37 HUC12 subwatersheds. After subdivisions, the framework was applied to 45 subwatersheds, which are referred to as 'decision units' (DUs) throughout the remainder of this document. A shapefile with DU boundaries is included in online supplemental materials (S7).

This spatial scale was selected for several reasons. The HUC12 scale is the highest-resolution watershed boundary universally available through public datasets in the Pacific Northwest. The designated management agency for the Lochsa subbasin, the US Forest Service (USFS), also uses HUC12 scale for assessing watershed conditions (USFS 2011). This approach also enables the framework to evaluate various landscape conditions (riparian shade, roads, harvest, etc.) at the same spatial scale within a hydrologically complete drainage network.

This framework is specific to temperature and to the Lochsa subbasin. It is not applicable to other water quality parameters or subbasins without modification and justification. The framework is specific to temperature because it includes a temperature criteria evaluation component, and because it evaluates anthropogenic landscape disturbances specifically for their potential to impact stream temperature. DEQ considers natural conditions assessments to be a pollutant-specific exercise (Mebane and Essig 2003) because the "physical, chemical, biological, or radiological conditions existing in a water body without human sources of pollution" (IDAPA 58.01.02.10.63) are pollutant-specific, and evaluating "where natural background conditions exceed any applicable water quality criteria as determined by the Department" (IDAPA 58.01.02.054.04) requires characterizing natural background conditions for each water quality parameter evaluated in a natural conditions assessment. The framework is specific to the

Lochsa subbasin because it uses data sources and decision thresholds that are specific to the Lochsa subbasin.

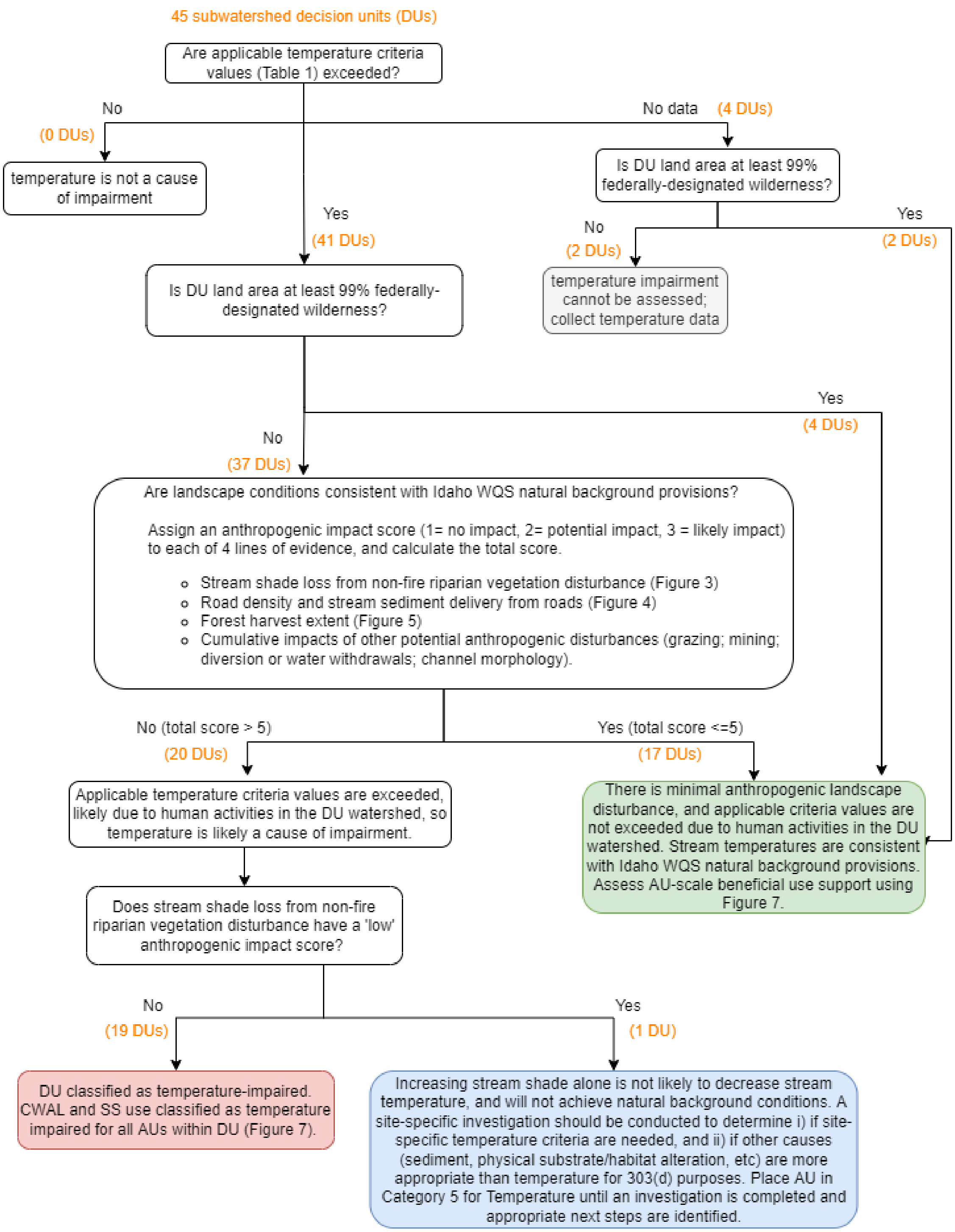

Figure 2. Lochsa temperature assessment subwatershed/decision unit (DU)scale classifications. Colors correspond to color coding in classifications results map Figure 10 and Table 3.

4.1 Temperature Criteria Exceedances

Available Lochsa subbasin temperature logger data were gathered and compiled into a project database. Data sources included a US Forest Service (USFS) database of 1993-2011 temperature logger data (NorWeST Clearwater Basin data, Chandler et al. 2016), 2012-2018 Idaho Department of Fish and Game (IDFG) data queried from Water Quality Portal (WQP, www.waterqualitydata.us) on 6-30-2021, 2012-2019 USFS data provided by Nez Perce-Clearwater Forest staff (Cynthia Valle, USFS, personal communication, October 2019), and DEQ 2020-2021 data. The assembled database includes over 4.3 million temperature observations collected 1993-2021 across 262 sites, 163 stream segments (NHDPlus v2 COMIDs), 41 of 45 decision units, and 92 of 120 stream assessment units.

Temperature data were screened for data quality and compared to criteria using an R software tool developed by DEQ for batch analysis of temperature data. The purpose of data quality screening was to flag and exclude days where temperature loggers may have been out of the water, malfunctioned, or recorded data unsuitable for comparison to temperature criteria. Screened temperature data were compared to CWAL and SS criteria at all sites with data, and to federal and Idaho BT criteria where applicable. Data screening and criteria analysis methods are documented in detail in supplemental materials (S2). All screening and criteria analyses are publicly accessible and computationally reproducible; the assembled temperature database, R scripts, R inputs, and outputs are available in supplemental materials (S2).

DUs were classified as exceeding temperature criteria in Figure 2 if any screened 1993-2021 data exceeded applicable criteria. Although Idaho's *Water Body Assessment Guidance* recommends only using external data collected within the last 5 years for CWA §303(d) listing decisions (DEQ 2016, section 4.2.1), the data window was expanded to encompass available data for this assessment because criteria value exceedances were large and consistent across years, and exceedances ≥ 5 years old were an excellent indicator of recent exceedances at the same site. Using all 1993-2021 data, Idaho salmonid spawning temperature criteria values were exceeded at all sites with temperature data (see results), and daily maximum temperatures exceeded the 13ºC salmonid spawning criteria by large magnitudes, in many cases by 3-5 ºC. At sites with multiple years of data, the presence or absence of criteria value exceedances was very consistent across years. Among 77 sites with ≥ 10 years of August data, mean August temperatures consistently exceeded 10ºC across years at nearly all sites, even those with a decreasing temperature trend (Supplemental Materials S2), and thus also consistently exceeded the salmonid spawning 9ºC daily average criterion during August. Therefore, within the Lochsa subbasin, available data indicate if salmonid spawning value exceedances occurred ≥ 5 years ago, those exceedances are very likely to persist now, and it is reasonable to use all available data when evaluating if any applicable criteria are exceeded within a DU.

For DUs with at least 99% federally-designated wilderness, the DU was classified as having stream temperatures consistent with natural background conditions (Figure 2). This includes four DUs with temperature data and two DUs without temperature data (Figure 2). Potential land management changes within <1% of DU land area were assumed insufficient to achieve criteria values throughout the entire DU considering the small land area available for management and that salmonid spawning criteria values were exceeded at all sites with data within the Selway-Bitterroot Wilderness, ranging from headwater streams deep within wilderness to 4th order streams at the mouth of subwatersheds (Supplemental

Information S2). This approach is consistent with Idaho's natural background guidance and waterbody assessment guidance (Mebane and Essig 2003 and DEQ 2016). For DUs without temperature data that are <99% wilderness area (2 DUs), temperature impairment cannot be assessed using this framework until temperature data are collected (Figure 2).

4.2 Do Landscape Conditions Indicate Temperature Exceedances Are Due to Human Activities in the Watershed?

In DUs with at least 99% federally designated wilderness land area, observed stream temperatures were due to factors other than human activities in the watershed and thus not in violation of temperature criteria. For DUs with temperature criteria exceedances and < 99% wilderness area, the framework considers multiple lines of evidence to classify landscape conditions in each DU as either meeting or not meeting natural background provisions requirements ("Yes" or "No" for landscape characteristics Figure 2).

Four landscape lines of evidence were evaluated—forest harvest, roads, stream shade, and the cumulative effect of other anthropogenic disturbances—and each was assigned an anthropogenic impact score (1= no impact, 2 = potential impact, or 3 = likely impact) reflecting the potential for a measurable stream temperature effect. Scores for riparian shade, harvest, and road characteristic conditions were assigned by comparing quantitative measures of shade, harvest, and roads to thresholds from relevant peer-reviewed scientific literature as described below and in Figures 3-5. The cumulative effect of other potential anthropogenic disturbance sources (riparian grazing; mining; irrigation, diversion and water withdrawals) were assigned a score using available relevant information and best professional judgement as described in Section 4.2.4.

If the total anthropogenic impact score exceeded 5, the DU was classified as not meeting Idaho natural background provision requirements in Figure 2. A total score > 5 occurred when any line of evidence has a 'likely impact' score, or if two or more lines of evidence have a 'potential' impact score. If the total anthropogenic impact score was ≤ 5, the DU was classified as having temperatures consistent with natural background conditions. A total score ≤ 5 occurred if all lines of evidence have a 'no impact' score, or if 3 lines of evidence have a 'no impact' score and only one line of evidence has a 'potential' impact score. Methods for assigning anthropogenic impact scores associated with each landscape line of evidence are described below.

4.2.1 Stream Shade

GIS analyses were used to estimate existing stream shade cover (%), potential stream shade cover (%), and the stream shade deficit (existing-potential). Existing and potential stream percent shade cover were estimated at 300 linear foot intervals using shade modeling methods developed by EPA (Supplemental Materials S4). Shade modeling used stream bankfull width, stream aspect, topographic angle, riparian vegetation height, riparian vegetation canopy cover, and road location as inputs to estimate existing stream percent shade cover. For existing shade estimates, model inputs were based on GIS datasets reflecting current conditions. To estimate potential shade, the same approach was used, except roads were excluded and vegetation height and canopy cover inputs were Potential Natural Vegetation (PNV) conditions that were utilized in the 2012 Lochsa Temperature TMDL (DEQ 2012). Specifically, targeted PNV conditions used to estimate potential shade conditions were developed using USFS estimates of vegetation ‘Historic Range of Variability’ (HRV) as described in Shumar and de Varona (2009) and therefore do account for natural vegetation variability to some degree. Estimated shade deficits therefore likely result primarily from human activities, but it is possible some natural vegetation change or disturbance processes are not accurately reflected in potential shade estimated at the 300 linear foot scale used here. Methods for estimating existing shade, potential shade, and shade deficits are described in detail in supplemental materials (S4).

Estimated shade deficits were compared to thresholds from relevant scientific literature to assign riparian shade anthropogenic impact scores (Figure 3). DU average shade deficit values were used to screen for riparian shade conditions very likely or very unlikely to have temperature impacts. DUs with an average riparian shade deficit > 15% were assigned a score of 3 (likely impact) based on experimental field studies with a Before-After-Control-Impact (BACI) design that suggested reach-scale (~1 km) shade decreases of > 15-20% for small streams can increase stream temperatures in that reach by more than 1ºC (Groom et al. 2011, Groom et al. 2018, Roon et al. 2021). We assumed DUs with average shade deficit > 15% were likely to have one or more reaches with shade deficit ‘hotspots’ and corresponding large magnitude reach-scale temperature increases that would overwhelm any potential downstream cooling processes.

DUs with an average riparian shade deficit < 6% were assigned a ‘no impact’ score based on field experiments with BACI design and modeling studies that reported measurable reach-scale (~1 km) temperature increases occurred when reach-scale riparian shade reduction magnitude exceeded 6% (Groom et al. 2011, Roon et al. 2021, Barnowe-Meyer et al. 2021). Although these studies quantified shade-temperature relationships at the reach scale, we believe applying them to subwatershed averages is reasonable. Experimental studies (Roon et al. 2021) and other literature indicate local temperature increases in shade-depressed reaches may not always persist downstream (Moore et al. 2005, Gravelle and Link 2007), and downstream temperature recovery depends in part on upstream temperature change magnitude (Davis et al. 2016, Roon et al. 2021). DUs with <6% average shade deficit are unlikely to have large local reach-scale temperature increases, and likely have capacity for cooling processes (baseflow inputs, hyporheic water or heat exchange, tributary inflows, downstream shade increases) within the DU to mitigate any measurable temperature increases from small magnitude shade deficits.

In DUs with 6-14.9% average shade deficit, impacts on stream temperature are less clear and an additional test was applied (Figure 3). Shade deficits within this range are not easily discernable from deficits that have no (<6%) or likely (>15%) impacts. Comparing predicted and field-measured existing shade revealed model error (|predicted % minus observed %|) magnitudes of 1.5 – 30.9% (average 10.8%, N = 10), with 3 sites having error magnitude >10% (Supplemental Materials S4). Second, within the 6-14.9% range, DU average shade deficit values may mask local shade deficit ‘hotspots’ that may strongly impact stream temperatures. Therefore, when DU average shade deficit was in the intermediate range of 6 – 14.9%, a second test was applied to evaluate if the DU has areas of higher shade loss that could be altering stream temperatures that were not evident in the DU average analysis. This second test evaluated the percent of DU stream miles with a shade deficit magnitude large enough to cause large local temperature increases that we assumed could not be mitigated by cooling processes (20%) (Groom et al. 2018, Roon et al. 2021). A score of 1 (no impact) was assigned if < 25% of stream miles had a shade deficit > 20%, and a score of 3 (likely impact) was assigned if ≥ 25% of stream miles had a shade deficit

> 20% (Figure 3). We assumed measurable temperature increases were likely persistent and widespread if >25% of DU stream miles had >20% shade deficit.

It is important to note that stream segments with recent (1999 through 2016) wildfire exposure based on Landscape Fire and Resource Management Planning Tools Program (LANDFIRE) data (LANDFIRE 2019) were not included when calculating both shade tests (Figure 3). Analyses indicated over 28% of the riparian network in the Lochsa subbasin has been exposed to recent fires, with higher percentages in DUs containing wilderness, and an analysis indicated that shade deficits were larger in fire-exposed areas. Wildfire-impacted segments were excluded because it is difficult to discern natural from human-caused shade deficits for these segments. Supplemental materials (S4) summarizes Lochsa subbasin wildfire patterns and effects on shade.

Within the Lochsa subbasin, USFS currently applies riparian forest management practices as defined in the 1987 Clearwater National Forest Plan (USFS 1987) and amended by PACFISH (BLM 1995) and a 1995 National Marine Fisheries Service Biological Opinion (NOAA 1995). For anadromous fish-bearing streams, USFS establishes riparian habitat conservation areas (RHCAs), generally 300 linear feet slope distance on each side of the stream, where USFS conducts no timber harvest or other forest management activities (Zach Peterson, Nez Perce-Clearwater Forest Planner, personal communication 9/22/21). The Nez Perce-Clearwater National Forest is currently engaged in a forest plan revision process, with a final revised plan scheduled for late 2022 or later. A finalized revised plan would establish riparian management practices that would replace current practices.

We believe our approach to applying shade thresholds (Figure 3) is conservative and protective for several reasons. First, while we excluded fire-impacted streams from shade analyses, we likely have imperfect fire extent information, and some reaches may have shade deficits due to recent or legacy wildfire impacts rather than human activities. Second, our approach assumes that any difference between existing and potential riparian shade at the site scale results only from human activities. In reality, shade deficits may result in part from natural processes not fully captured in potential shade estimates. Modeling predicted shade deficits within Wilderness outside wildfire-impacted areas in some cases (see results), which suggests our approach is conservative.

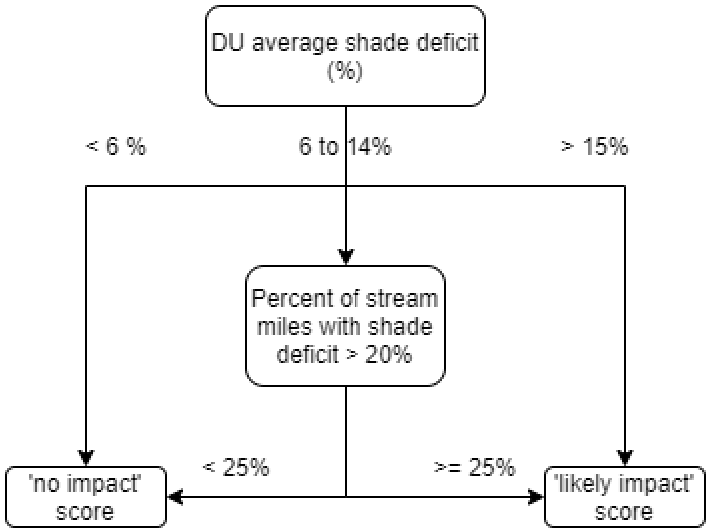

Figure 3. Approach to assigning anthropogenic impact scores for the stream shade line of evidence in Figure 2.

4.2.2 Roads

Road impacts on riparian shade are included in existing shade estimates described above (see Supplemental Materials S4). However, roads may also impact stream temperatures by altering stream flow, stream morphology, and sediment loading, transport, and deposition. A two-step process was used to assign an anthropogenic impact score (1= no impact, 2 = potential impact, 3 = likely impact) to DU road conditions (Figure 4). First, DUs with road densities < 0.7 miles/miles^2 and > 4.6 miles/miles^2 were assigned no and likely impact scores, respectively. These thresholds are based on those used by USFS to classify road densities and their potential impacts, and correspond to USFS very low-low, and very high road density classifications (USFS 1996). Our 0.7 miles/miles^2 threshold is similar to the 0.5 km/km^2 (0.8 miles/miles^2) threshold used by USFS as a roads criterion for PacFish/InFish Biological Monitoring Program (PIBO) reference sites (Roper et al. 2019). We assumed that road impacts on temperature do not have an impact at densities < 0.7 miles/miles^2 and have a likely impact at densities > 4.6 miles/miles^2.

For intermediate road densities (0.7 to 4.6 miles/miles^2), a second test was applied to help discern if roads are likely to alter stream temperatures (Figure 4). Stream sediment loading from road surfaces (tons/yr/km^2) was estimated using a standard Geomorphic Road Analysis and Inventory Package Lite (GRAIP-Lite) model (Nelson et al. 2019) run conducted by EPA. Anthropogenic impact scores were assigned as follows: 1 (no impact) where estimated sediment loads were < 5 tons/yr/km^2, 2 (potential impact) where estimated sediment loads were 5 – 9 tons/yr/km^2, and 3 (likely impact) where estimated loads were > 10 tons/yr/km^2. These ranges were selected based on research indicating background sediment yields in forested watersheds during quiescent periods (i.e., non-storm periods) are around 10 tons/yr/km^2 (Kirchner et al. 2001, Goode et al. 2012). While the watersheds evaluated in these studies include land use features and are not natural areas, the activities occuring in these basins (roads, harvest, small towns) do not dramatically affect the sediment load during quiescent periods. Therefore, we believe using < 5 tons/yr/km^2 (i.e., half of the estimated background load) as the no impact threshold for the second test is conservative. GRAIP-Lite is a tool intended primarily for prioritizing road management efforts rather than producing highly accurate sediment loading estimates. Also, the background sediment loads for the Lochsa are not established, and the relationship between sediment loading magnitude and stream temperature changes is unknown. Thus, this line of evidence has greater uncertainty than the shade metrics. We maintained a potential impact rating outcome for the second step in the roads line of evidence because of this uncertainty, and as part of the conservativism (protectiveness) incorporated in the framework depicted in Figure 4.

Road density analyses and the GRAIP-Lite model run used Nez Perce-Clearwater National Forest roads GIS layers. These layers do not include many of the privately-owned logging roads present on private parcels in the upper watershed. However, the potential effects of land use by private timber companies in the upper watershed were addressed through the forest harvest line of evidence (section 4.2.3).

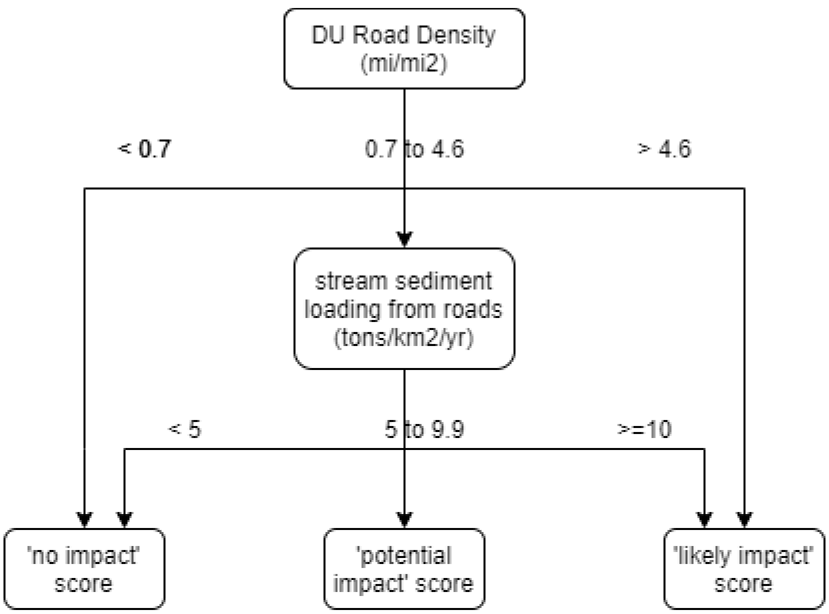

Figure 4. Approach to assigning anthropogenic impact scores for the road density and road sediment production lines of evidence in Figure 2.

4.2.3 Forest Harvest

Forest harvest within riparian areas can have large impacts on stream temperatures (Moore et al. 2005, Sweeney and Newbold 2014). Stream shade analyses (section 4.2.1) capture impacts of any riparian vegetation disturbance on stream shade, including riparian harvest. Forest harvest outside the riparian zone also has potential to increase stream temperature, although whether non-riparian harvest impacts temperature at all and temperature effect magnitudes appear highly variable and case-specific (Moore et al. 2005, Gomi et al. 2006, Pollock et al. 2009, Blandon et al. 2016). This framework takes a conservative approach and assumes any forest harvest activity outside riparian areas has potential to increase stream temperature if harvest is sufficiently extensive, regardless of technique, watershed characteristics, distance from the stream, or other factors that may mediate temperature impacts.

Within each DU, forest harvest extent was evaluated using Nez Perce-Clearwater National Forest GIS layers. DU percent harvested area, and DU percent privately owned area were used to assign anthropogenic impact scores (Figure 5). Each DU with < 10% harvested area, and > 40% harvested area was assigned scores of 1 (no impact) and 3 (likely impact), respectively. Pollock et al. 2009 reported temperature criteria violations were not observed in western Washington streams with less than 25% of upstream watershed area exposed to historic harvest activities, and Mebane and Essig (2003) proposed >20% forest harvest could indicate non-natural conditions. USFS used a < 5% harvest area as a criterion for identifying PIBO reference sites (Roper et al. 2019). For DUs with intermediate levels of harvest (10 to 39.9%), a second step assigned scores based on the percent privately-owned area. This metric was used because forest harvest data were only available for USFS lands. GIS analyses indicated forest vegetation is approximately 16% to 35% shorter within privately managed forests within Upper Lochsa basin DUs, as compared to adjacent USFS forests in the same DUs. This indicated a substantial amount of (and more recent) harvest has occurred in the checkerboard pattern of privately-owned timber lands in the upper watershed (Figure 6). We therefore used a 20% private land area threshold as a proxy for private timber harvest in the upper watershed (Figure 5). This approach is specific to the Lochsa subbasin and may not be applicable elsewhere.

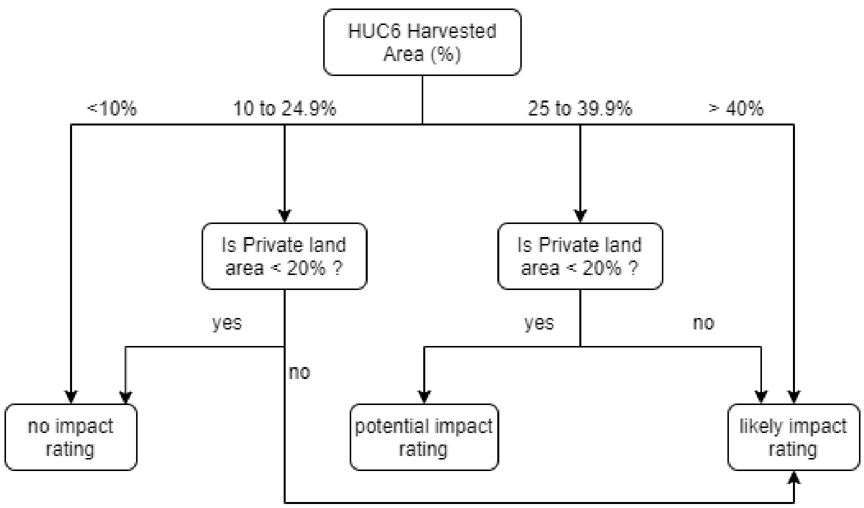

Figure 5. Approach to assigning anthropogenic impact ratings for forest harvest.

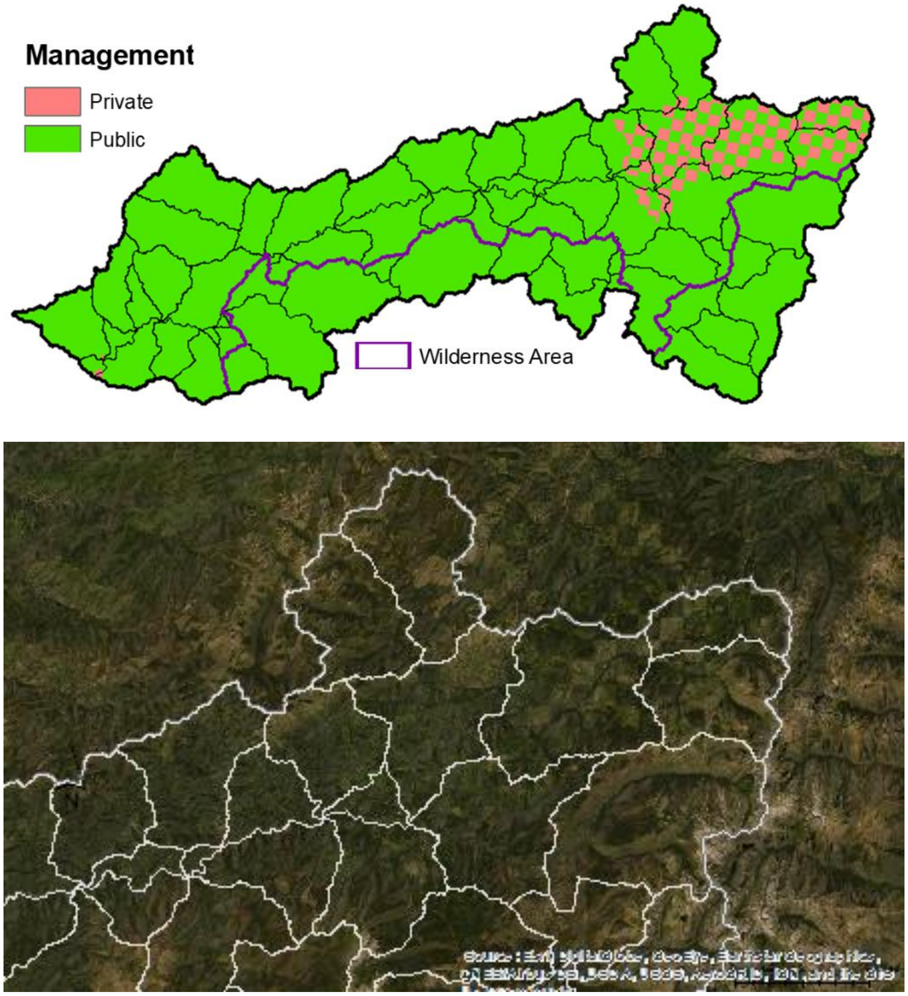

Figure 6. Private ownership patterns in the upper Lochsa watershed.

4.2.4 Other Anthropogenic Landscape Disturbances

Timber harvest, road development, and riparian shade reduction are three anthropogenic landscape changes that can affect stream temperatures. In the Lochsa subbasin, other potential anthropogenic landscape changes could occur through mining, livestock grazing, water diversion, withdrawals, or stream channel modification. Because it is very challenging to develop and apply quantitative thresholds such as those in Figures 3 – 5 for these landscape characteristics, we used best professional judgement to assign an anthropogenic impact score of 1 (low impact), 2 (potential impact), or 3 (likely impact) to the cumulative effect of all these potential disturbances, where applicable. Table 2 presents data sources used to evaluate these landscape characteristics.

Table 2. Data sources used to evaluate other anthropogenic disturbances. Shapefiles used are included in supplemental materials (S7).

Disturbance Type	Data Source
Historic Mining	Idaho Geological Survey's 'Database of the Mines and Prospects of Idaho' version 1.2021
Recent Grazing	Shapefile with BLM and USFS grazing allotments in Idaho, based on 3/19/2021 BLM and USFS data.
Irrigation, Diversion, Or Water Withdrawals	Idaho Department of Water Resources points of diversion shapefile dated 01/13/2021. Water rights GIS layers will be used to identify where water rights exist. Anthropogenic impact ratings will be assigned based on professional judgement.

For each DU, the number, location, and characteristics of mining, grazing, and water right disturbances were considered when assigning scores. For mines, the number of mines, and database information on disturbance extent was considered. The database includes both prospects and productive mines, and indicates whether each site was 'exploratory only', or there is evidence of production, including placer activity, or surface or underground mining. If there was only one mine within a DU classified more than 'exploratory only', and that mine was not near a stream, the mine was not considered a disturbance that could potentially affect stream temperatures. For water rights, the type of water right (consumptive vs. non-consumptive), source (groundwater vs surface water), number of water rights, and total consumptive diversion rate were considered when assigning anthropogenic impact scores. For grazing, the presence and extent of grazing allotments were considered. No GIS data sources were available to allow for a systematic analysis of anthropogenic stream channel modification. However, channel modification typically occurs through the anthropogenic activities evaluated in other components of the framework – roads, harvest, mines, grazing. There are no Idaho Pollution Discharge Elimination System (IPDES) individual permits in the subbasin. A brief narrative statement justifying the assigned other anthropogenic impacts score was written and included in supplemental materials file S6 along with counts of mines, diversions, and water rights in each DU.

4.3 Climate Change

In the Pacific Northwest, climate change is projected to increase stream temperatures (Isaak et al. 2017), change stream flow regimes (Kormos et al. 2016), and change vegetation communities (Peterson et al. 2014), among other impacts. However, climate change is not an explicit part of the framework structure (Figure 2). The WQS define natural background conditions as those "in a water body without human sources of pollution within the watershed" (IDAPA 58.01.02.10.63). Therefore, compliance with the WQS natural background provisions must primarily be assessed at the watershed scale and considers whether there are human sources of pollution *within* the watershed (Mebane and Essig 2003). Consistent with this, the framework was applied at the subwatershed scale, and evaluated the presence and extent of multiple types of anthropogenic disturbances within each subwatershed. Anthropogenic climate change is a global disturbance caused by global and regional patterns of human activities, and therefore climate change impacts to streams, including those in the Lochsa subbasin, come primarily from human pollution sources located outside subbasin boundaries. Consistent with the WQS definition of natural background, DEQ excludes all global and regional climatic patterns, including anthropogenic climate change, from the scope of natural conditions assessments, and considers prevailing climactic conditions to be part of background conditions (Mebane and Essig 2003).

In addition, climate change impacts on stream temperatures are difficult to predict for Lochsa streams. While stream temperatures in the Pacific Northwest are generally projected to increase 0.17ºC per decade on average (Isaak et al. 2017), substantial local variation in the magnitude and direction of stream temperature responses within and across watersheds is expected (Mayer et al. 2012, Luce et al. 2014, Isaak et al. 2017). Long-term trend analyses have documented both warming and cooling trends in Pacific Northwest streams (Arismendi et al. 2012, Isaak et al. 2012). Using the temperature database compiled for this project, we evaluated mean August temperature (MAT) trends for stream segments (NHDPlus v2 COMIDs) with at least 10 years of August temperature data (see supplemental materials S2.2). Of the 77 segments with sufficient data, 16 had a statistically significant temperature trend ($p < 0.05$) based on a Mann-Kendall trend test, and temperature trends were negative (cooling) in 14 of these 16 streams. Across all 77 COMIDs included in the trend analysis, the distribution of Theil-Sen slope values also skewed negative (see supplemental materials S2.2). These trend analyses are not comprehensive because they focus on only one temperature metric, and trend analysis results can be affected by the amount of data available (Arismendi et al. 2012). However, combined with regional studies highlighting local variability in stream temperature responses to climate change, and research projecting that some Lochsa streams will remain cold enough to serve as cold water refugia for salmonids as climate increases (Isaak et al.2015), these patterns suggest that projected average regional warming trends should not be assumed to apply everywhere in the Lochsa subbasin, especially at the framework's subwatershed scale.

4.4 Assumptions

The framework is based on several assumptions, and some are described above. In addition to considering climate change as part of background, the framework assumes thresholds applied in Figures 3-5 are reasonably representative of thresholds associated with natural conditions in the Lochsa subbasin. Exceedance of shade, roads, and harvest thresholds defined in Figures 3-5 are assumed to result from human activities rather than natural phenomena. The framework assumes GIS data sources used are sufficiently representative of landscape conditions. It also assumes stream shade, roads, and forest harvest are the landscape variables with the largest magnitude effect on stream temperature in the subbasin. Shade analysis methods assumed wildfire impacts on riparian shade were not anthropogenic, which is consistent with the definition of natural background conditions found in IDAPA 58.01.02.10.63. We believe this assumption is reasonable for the Lochsa subbasin, because most recent fire activity occurred within or on the boundaries of federally-designated wilderness (supplemental materials S4).

4.5 Application to Idaho's Integrated Report

In Idaho's Integrated Report, DEQ must report beneficial use support status at the assessment unit (AU) spatial scale (see 2022 IR section 2.1.1). For Idaho's 2022 Integrated Report, DEQ assessed CWAL and SS beneficial use support for each Lochsa stream AU based on DU outcomes and other available data. DU outcomes were used to evaluate whether temperature impaired CWAL and or SS beneficial uses for each stream AU within each DU.

The process used to assess AU CWAL and SS support status based on DU outcomes is documented in Figure 7. For tributary AUs within DUs exceeding numeric criteria values likely due to human activities, CWAL and SS were assessed as not supporting due to temperature. These AUs were placed on Idaho's 303(d) list due to temperature impairment (IR category 5) or in IR Category 4a if a PNV temperature TMDL has already been developed and approved (DEQ 2012a, EPA 2020). For the main stem Lochsa

River, DEQ placed all 6 main stem AUs on the 303(d) list (IR Category 5) due to temperature impairment because multiple tributary DUs draining into the main stem exceeded numeric criteria values due to human activities (see results), and therefore DEQ presumed main stem criteria value exceedances were also affected by human activities.

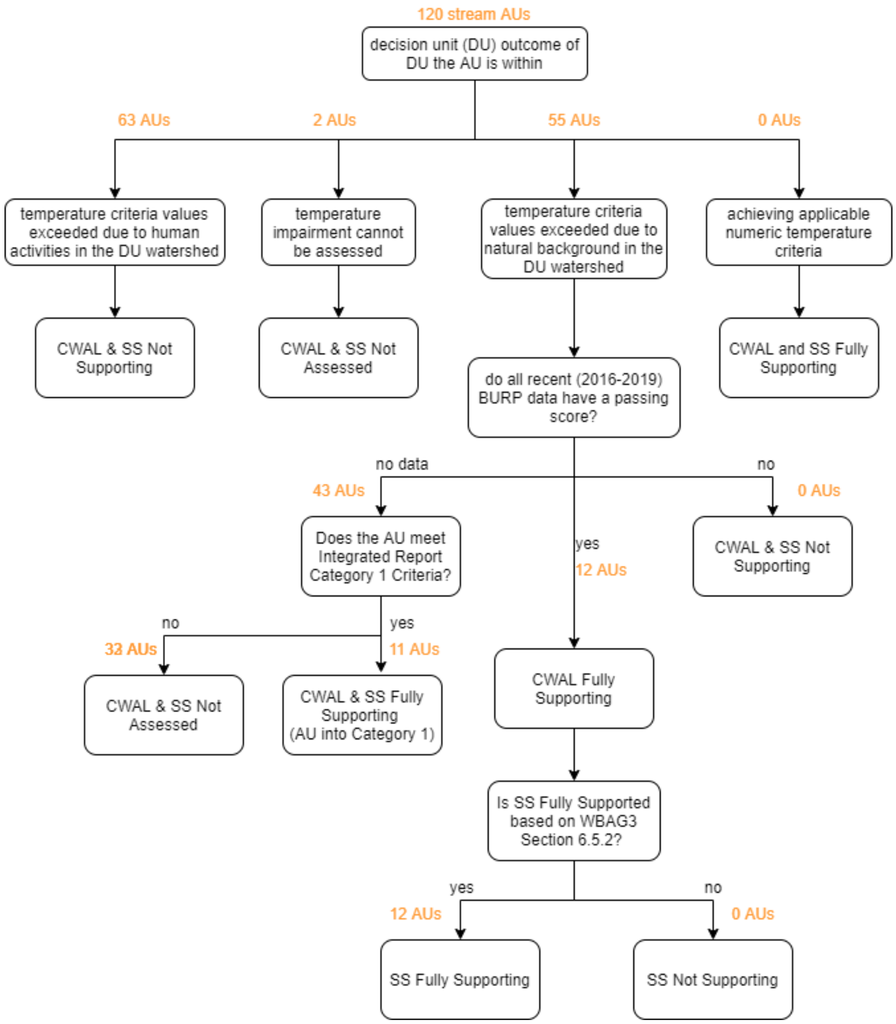

Figure 7. Logic used to make CWAL and SS support status decisions based on DU outcomes.

For tributary AUs within DUs exceeding numeric criteria values due to natural background conditions, DEQ evaluated additional available lines of evidence to assess support of CWAL and SS uses. This approach is consistent with the IDAPA 58.01.02.054.04 requirement that when criteria values are exceeded due to natural background, those natural background exceedances cannot be the only line of evidence used to determine impairment. For these AUs, DEQ also evaluated available Beneficial Use Reconnaissance Program (BURP) data (DEQ 2016). If the AU had one or more recent (2016-2019) BURP sites with data, and all BURP sites had passing score calculated as described in DEQ (2016), CWAL was assessed as fully supporting. If one or more recent BURP sites did not have a passing score, DEQ assessed CWAL and SS as not supporting. If no BURP data were available, DEQ evaluated whether the AU was fully within federally-designated wilderness or 2008 Idaho Roadless Rule “Wildland Recreation” area, and therefore met Integrated Report Category 1 criteria. For AUs without BURP data that met Category 1 criteria, CWAL and SS were assessed as fully supporting and the AU was placed in IR Category 1. If no BURP data were available and Category 1 criteria were not met, CWAL and SS were not assessed (Figure 7). Although the DUs these AUs fall within indicated temperature criteria were not violated due to human activities, negative evidence for temperature impairment is not necessarily positive evidence for CWAL and SS support, so DEQ conservatively classified CWAL and SS as not assessed in these cases. For tributary AUs within DUs exceeding numeric criteria due to natural background conditions where recent BURP data indicated CWAL support, DEQ applied standard protocols to BURP and other available data to assess SS support (IDEQ 2016, section 6.5.2). CWAL and SS outcomes for all 120 Lochsa stream AUs are documented in Supplemental Materials (S10).

Outcomes of this framework are specific to temperature and were used only to make CWAL and SS beneficial use support calls. To assess support of contact recreation uses for Lochsa AUs, DEQ independently evaluated available *Escherichia coli* data using standard protocols (DEQ 2016). DEQ's CWAL and SS use support status calls for all 120 Lochsa stream AUs are provided in Supplemental Materials S10 Assessment results for other uses are available through Idaho's full 2022 Integrated Report.

5.0 Results

Stream temperature data were available for 41 of 45 DUs. One or more of Idaho's numeric temperature criteria were exceeded in all 41 DUs with data. Of the 41 DUs with data, CWAL criteria were exceeded in 23 DUs (56%) and SS criteria were exceeded in 41 AUs (100%). EPA BT and ID BT criteria were exceeded in all DUs where they applied. See supplemental materials S2 for detailed criteria exceedance results.

Modeled riparian shade deficit results are mapped by 300 ft stream segments in Figure 8. Nineteen DUs (42%) had a 'no impact' shade score (score = 1) and 26 DUs (58%) had a 'likely impact' shade score (score = 3) (Table 3). Eighteen of 26 DUs (70%) with a 'likely impact' shade score were assigned this score due to DU average shade deficit > 15%, and 8 (30%) were assigned this score because ≥ 25 of stream miles had shade deficit > 20% (Figure 3).

Though DUs with at least 99% of wilderness were not ultimately assessed using the anthropogenic impact scores (see Figure 2), DEQ evaluated the scores for these DUs to gain an understanding of how conservative the framework is. Among DUs with a 'likely impact' shade score, four were entirely within wilderness (Upper Big Sand Creek, Hidden Creek, Upper Colt Killed Creek, Upper Warm Springs Creek), and two had at least 99% wilderness area (Wind Lakes Creek, Old Man Creek). Of these six wilderness DUs with a 'likely impact' shade score, four had over 40% of the DU stream miles excluded from shade analyses due to wildfire impacts. These 'likely impact' scores in wilderness could be an artifact of incomplete information on wildfire extent and limited stream network miles used for calculating Figure 3 statistics. However, two of these DUs (Wind Lakes Creek, Old Man Creek) had less than 10% of stream miles excluded, and still had a 'likely impact' shade score due to average shade deficit > 15% despite at least 99% wilderness area.

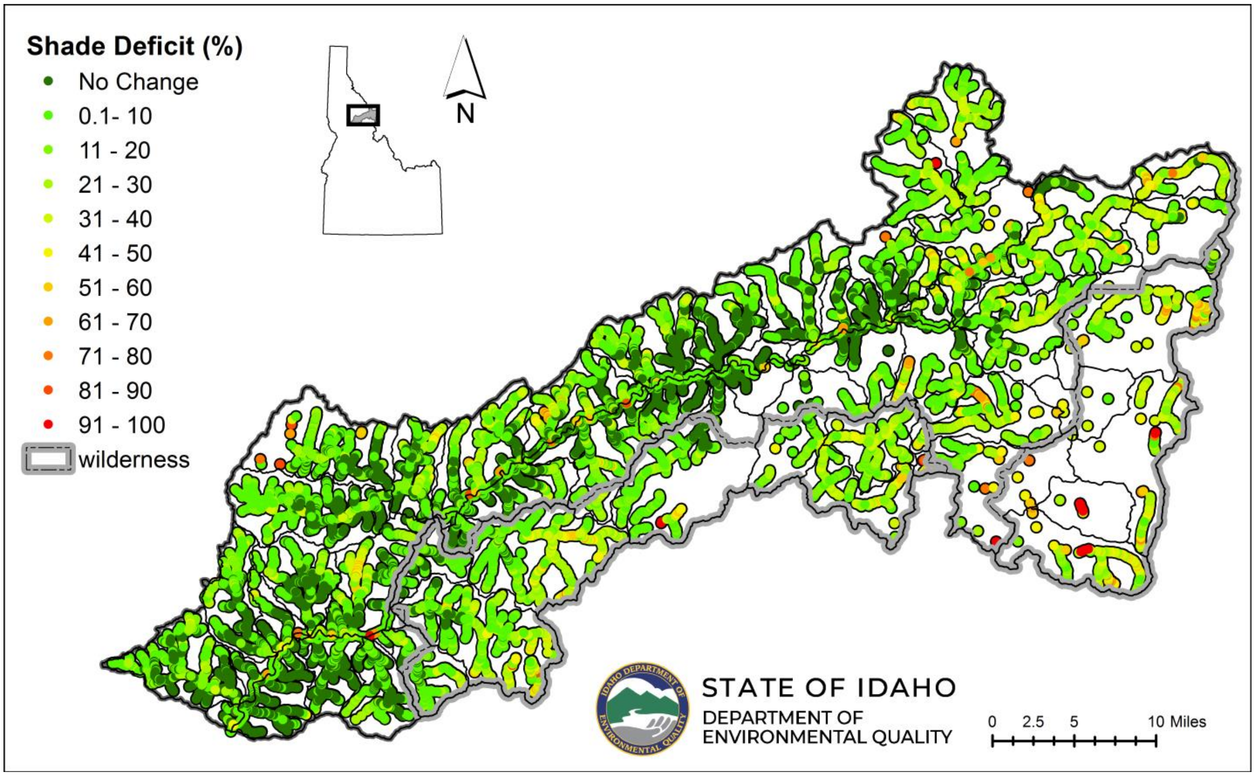

Figure 8. Stream shade deficit (existing-potential) results at 300 linear ft intervals for stream segments not impacted by wildfire.

For roads, 38 DUs had a 'no impact' roads score (score =1), with 28 AUs having road densities below the 0.7 mi/mi^2 threshold automatically triggering a no impact score (Figure 3). The 10 other DUs designated as "no impact" were classified as such because of road sediment modeling and stream delivery results below the 5 tons/km^2/yr threshold (Figure 4). Five DUs were assigned a 'potential' impact roads rating, and 2 DUs were assigned a 'likely impact' roads rating as a result of this road sediment modeling (Figure 3, Table 3).

For harvest, 37 DUs had a 'no impact' harvest score (score =1) (Table 3); 33 had a 'no impact' score due to less than 10% harvest area (Figure 5). One DU had a 'potential impact' harvest score (score =2), and 7 DUs had a 'likely impact' harvest score (score = 3) (Table 3).

The spatial distribution of water diversions, mine/prospect sites, and grazing allotments is mapped in Figure 9. Three DUs (Pete King Creek, Lower Big Sand Creek, Glade Creek southern half) were assigned a 'potential impact' other anthropogenic impacts score, and all other DUs were assigned a 'low impact' other anthropogenic impacts score (Table 3). The Pete King Creek DU was assigned a 'potential impact' score because it had a grazing allotment, and also had 7 mine/prospect sites, some with documented evidence of production and mining-related disturbances. Pete King Creek was the only DU with a grazing allotment. The Lower Big Sand Creek DU was assigned a 'potential impact' score because there were four mine/prospect sites, including three with evidence of placer mining. The Glade Creek southern half DU was assigned a 'potential' impact score because water diversions on Lottie Creek represented a large fraction of Lottie Creek predicted low flows. Fourteen DUs had one or more mine/prospect sites, but the mines database classified only a handful of sites as more than 'exploratory only' with evidence of production activity. Thirty-four DUs had one or more points of diversion. In most cases, diversions were from ground water, rights were non-consumptive, or the total consumptive diversion rate was very small (typically 0.04 cfs or less).

Outcomes by DU are mapped in Figure 10 and summarized in Table 3. Complete results for each framework component by DU are available in supplemental materials S6. Among the 45 DUs, 23 were classified as natural and not temperature-impaired, 19 were classified as temperature-impaired, one (Pete King Creek) was classified as temperature-impaired but needing further investigation, and 2 could not be assessed for temperature impairment because temperature data were not available (Figure 2). Though Pete King Creek is considered impaired for temperature and placed into Category 5, DEQ has flagged it for further investigation since shade targets were met and increasing shade is not likely to decrease stream temperature.

Among the 23 DUs classified natural for temperature, none had grazing allotments, and three DUs had one mine/prospect site (Figure 9). In each of these cases, the mines database indicated either the site was 'exploratory' only, or there was no evidence of production. Of the DUs classified as natural for temperature, 16 had one or more points of water diversion. The water rights were either non-consumptive, or the total combined consumptive diversion rate with a DU was very small, 0.04 cfs or less in all DUs except the two Glade Creek DUs. The northern Glade Creek DU (DU # 9 in Table 3 north side of Lochsa River), had a combined consumptive diversion rate was 0.21 cfs, but diversions were ground water rights located away from the stream, so a 'low impact' score was assigned. The southern Glade Creek DU (DU #3 in Table 3, south side of Lochsa River) also had a high combined consumptive diversion rate, however all but 2 diversions were ground water rights associated with a resort and located away from tributary streams. Two surface water rights on Lottie Creek had a combined diversion rate of 0.14 cfs, which represent nearly all the 30-day 5-year low flow predicted by StreamStats (USGS 2021), so this DU was assigned a 'potential impact' other impacts score. The southern Glade Creek DU still had a total score of 5 and thus met natural conditions provisions (Figure 2, Table 3).

CWAL and SS beneficial use support outcomes are mapped in Figure 11. A table with temperature impairment outcomes for all 120 Lochsa stream AUs is included in Supplemental Materials (S10). Based on DU results, 57 of 114 (50%) tributary AUs were classified as temperature-impaired in Idaho's 2022 Integrated Report. Of these, 53 were placed on Idaho's 303(d) list for temperature, and 4 had an existing temperature TMDL (DEQ 2012) and were placed in IR category 4a. Two tributary AUs (ID17060303CL001_01, ID17060303CL061_02) were categorized as impaired by temperature with an approved TMDL (IR Category 4a) in Idaho's 2018/2020 IR, and temperature was delisted as a cause of impairment for the 2022 IR based on framework outcomes. All six AUs comprising the Lochsa main stem were classified as impaired and placed on Idaho's 303(d) list.

55 of 114 (48%) tributary AUs were classified fully supporting CWAL and SS uses. Of these, 23 had BURP data indicating full support of CWAL. All BURP data in DUs classified as natural for temperature had a passing score. 32 of these AUs had no BURP data. 11 of the 32 AUs without BURP met Idaho's Integrated Report Category 1 landscape criteria.

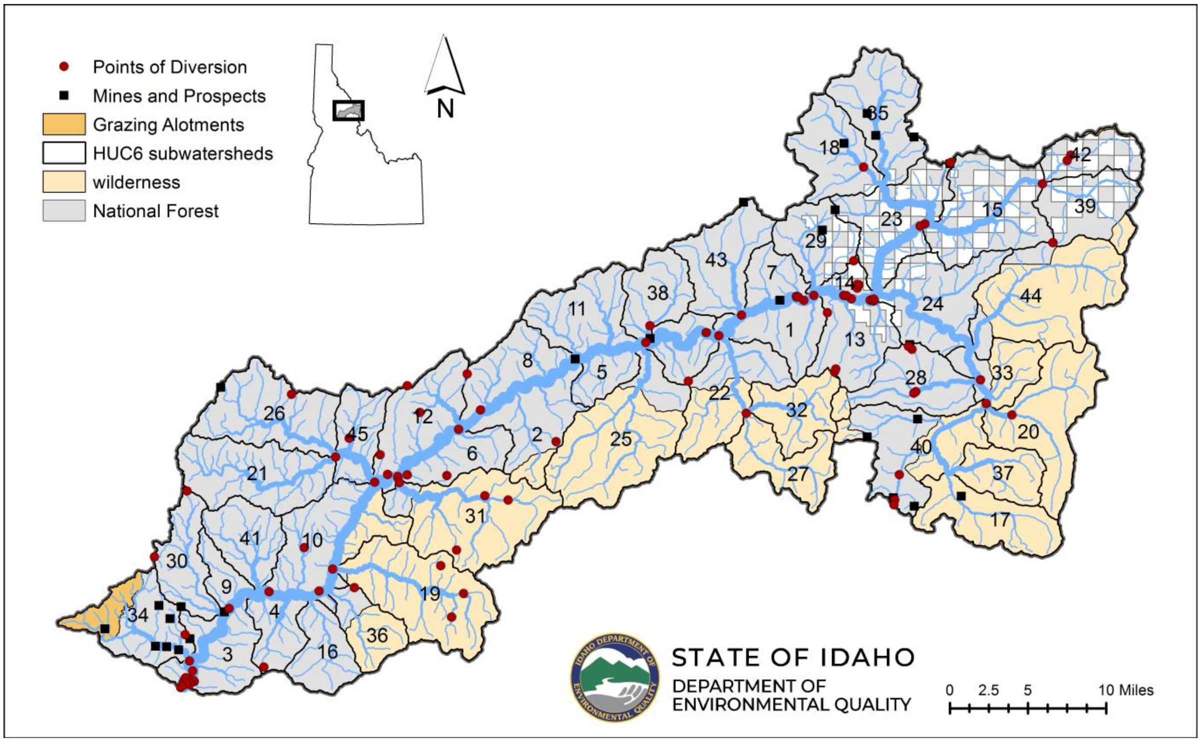

Figure 9. Locations of water diversion points, mine/prospect sites, and grazing allotments. Numbers correspond to subwatershed/decision unit (DU) numbers in Table 2.

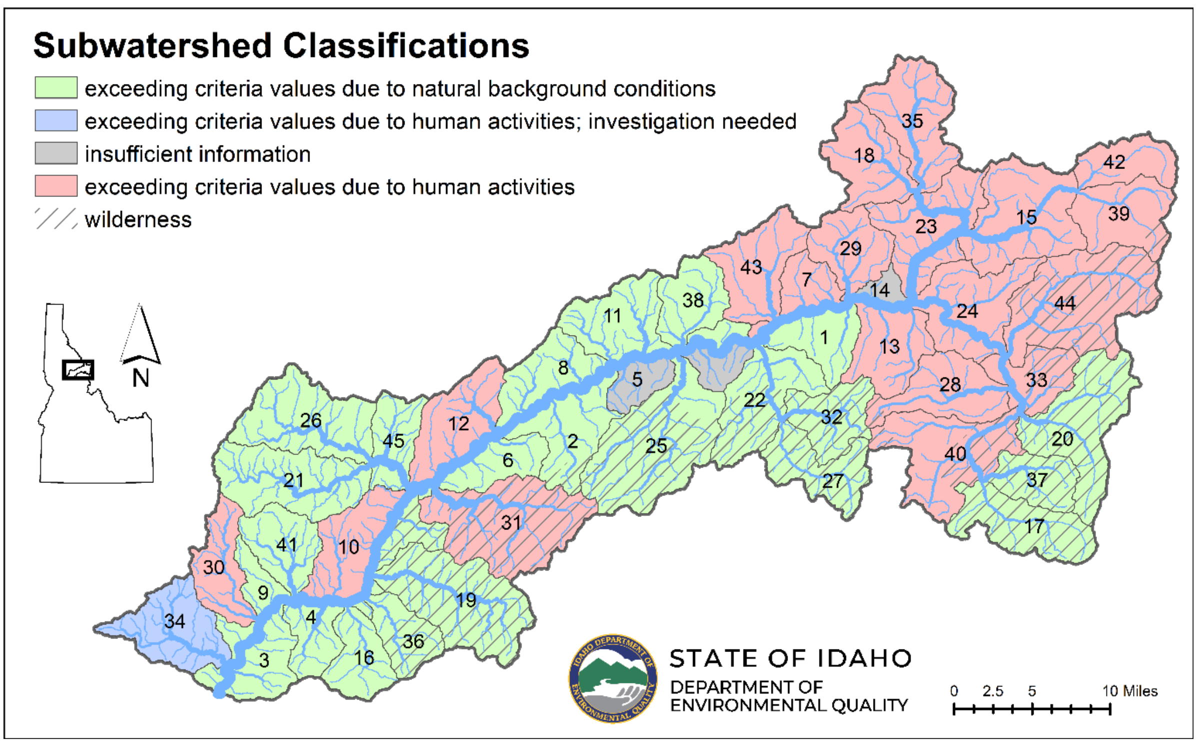

Figure 10. Subwatershed/decision unit (DU) classifications. Numbers correspond to decision unit numbers in Table 2.

Table 3. Subwatershed/decision unit (DU) classifications. See supplemental materials S6 for full results by DU. DU #s correspond to numbers in Figures 9-10.

DU #	HUC6	DU Name	Wilderness %	Criteria Exceeded	Shade Score	Roads Score	Harvest Score	Other score	Total Score	Classification
1	170603030304	Wendover Creek-Lochsa River (South)	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
2	170603030504	Stanley Creek-Lochsa River (South)	8	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
3	170603030708	Glade Creek-Lochsa River (South)	0	Y	1	1	1	2	5	exceeding criteria values due to natural background conditions
4	170603030704	Bimerick Creek-Lochsa River (South)	19	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
5	170603030503	Weir Creek-Lochsa River (South)	0	no data	1	1	1	1	4	insufficient information
6	170603030506	Bald Mountain Creek-Lochsa River (South)	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
7	170603030304	Wendover Creek-Lochsa River (North)	0	Y	3	3	3	1	10	exceeding criteria values due to human activities
8	170603030504	Stanley Creek-Lochsa River (North)	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
9	170603030708	Glade Creek-Lochsa River (North)	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
10	170603030704	Bimerick Creek-Lochsa River (North)	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
11	170603030503	Weir Creek-Lochsa River (North)	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
12	170603030506	Bald Mountain Creek-Lochsa River (North)	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
13	170603030301	Walton Creek-Lochsa River (South)	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
14	170603030301	Walton Creek-Lochsa River (North)	0	no data	3	2	1	1	7	insufficient information
15	170603030103	Lower Brushy Fork	0	Y	3	2	3	1	9	exceeding criteria values due to human activities
16	170603030703	Fire Creek	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
17	170603030201	Upper Big Sand Creek	100	no data	3	1	1	1	6	exceeding criteria values due to natural background conditions

DU #	HUC6	DU Name	Wilderness %	Criteria Exceeded	Shade Score	Roads Score	Harvest Score	Other score	Total Score	Classification
18	170603030105	Fox Creek-Boulder Creek	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
19	170603030701	Old Man Creek	99	Y	3	1	1	1	6	exceeding criteria values due to natural background conditions
20	170603030203	Upper Colt Killed Creek	100	Y	3	1	1	1	6	exceeding criteria values due to natural background conditions
21	170603030601	Upper Fish Creek	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
22	170603030403	Lower Warm Springs Creek	53	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
23	170603030106	Lower Crooked Fork	0	Y	3	2	3	1	9	exceeding criteria values due to human activities
24	170603030208	Lower Colt Killed Creek	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
25	170603030502	Lake Creek	83	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
26	170603030602	Hungery Creek	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
27	170603030401	Upper Warm Springs Creek	100	Y	3	1	1	1	6	exceeding criteria values due to natural background conditions
28	170603030205	Colt Creek	8	Y	3	1	1	1	6	exceeding criteria values due to human activities
29	170603030302	'Imnamatnoon Creek	0	Y	3	2	3	1	9	exceeding criteria values due to human activities
30	170603030706	Canyon Creek	0	Y	3	2	3	1	9	exceeding criteria values due to human activities
31	170603030505	Boulder Creek	92	Y	3	1	1	1	6	exceeding criteria values due to human activities
32	170603030402	Wind Lakes Creek	99	Y	3	1	1	1	6	exceeding criteria values due to natural background conditions
33	170603030206	Middle Colt Killed Creek	69	Y	3	1	1	1	6	exceeding criteria values due to human activities
34	170603030707	Pete King Creek	0	Y	1	3	2	2	8	exceeding criteria values due to human activities & investigation needed
35	170603030104	Upper Crooked Fork	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
36	170603030702	Split Creek	72	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
37	170603030202	Hidden Creek	100	no data	3	1	1	1	6	exceeding criteria values due to natural background conditions

DU #	HUC6	DU Name	Wilderness %	Criteria Exceeded	Shade Score	Roads Score	Harvest Score	Other score	Total Score	Classification
38	170603030501	Postoffice Creek	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
39	170603030102	Spruce Creek	6	Y	3	1	3	1	8	exceeding criteria values due to human activities
40	170603030204	Lower Big Sand Creek	41	Y	3	1	1	2	7	exceeding criteria values due to human activities
41	170603030705	Deadman Creek	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions
42	170603030101	Upper Brushy Fork	0	Y	3	1	3	1	8	exceeding criteria values due to human activities
43	170603030303	Waw'aalamnime Creek	0	Y	3	1	1	1	6	exceeding criteria values due to human activities
44	170603030207	Storm Creek	86	Y	3	1	1	1	6	exceeding criteria values due to human activities
45	170603030603	Lower Fish Creek	0	Y	1	1	1	1	4	exceeding criteria values due to natural background conditions

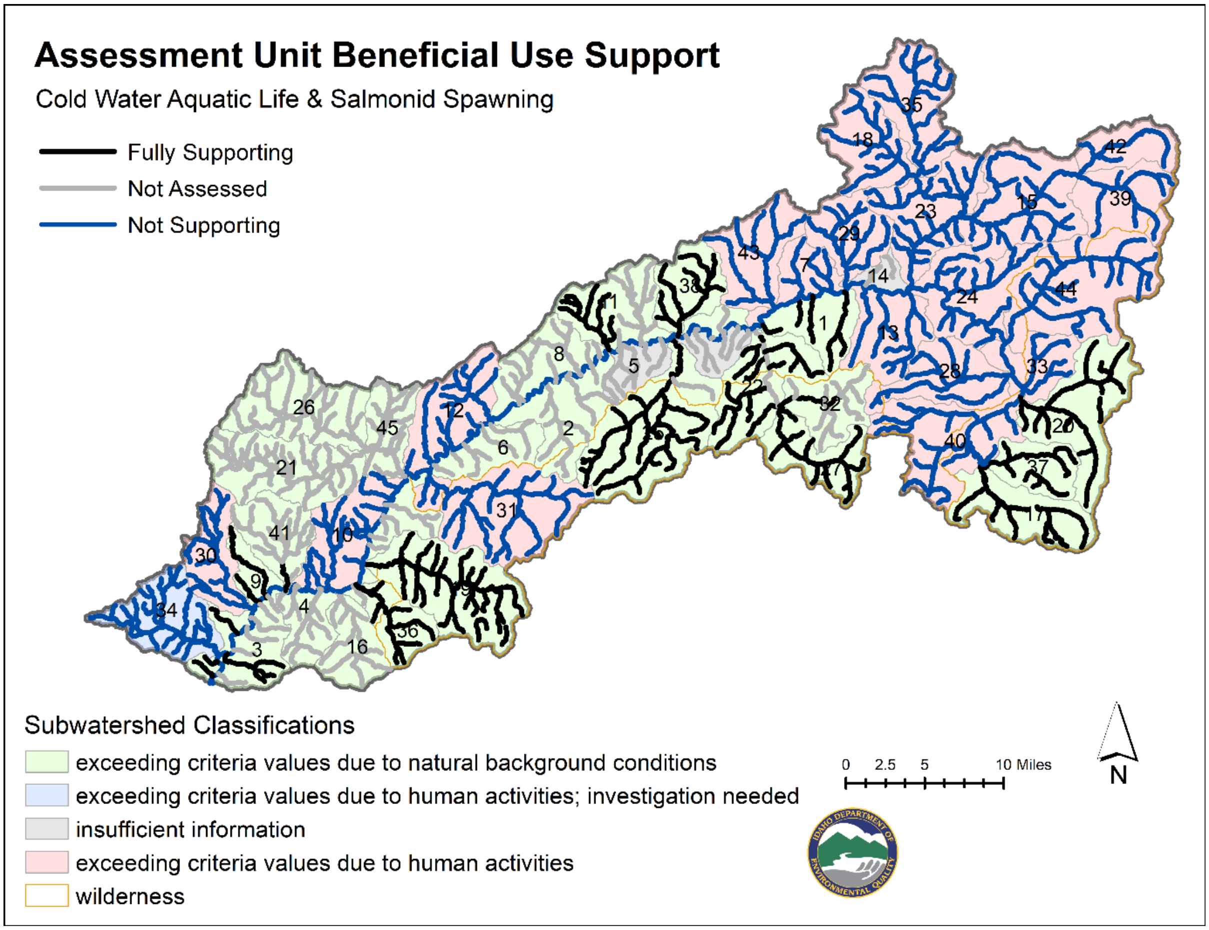

Figure 11. Assessment unit Cold Water Aquatic Life and Salmonid Spawning beneficial use support outcomes.

6.0 Discussion

The objective of this assessment was to assess whether temperature impairs CWAL and or SS beneficial uses for all 120 stream AUs in the Lochsa subbasin. This objective was accomplished by developing and applying a two-component assessment framework. First, multiple lines of evidence were used to classify each subwatershed decision unit (DU) as either (1) achieving applicable numeric temperature criteria, (2) exceeding applicable numeric temperature criteria values likely due to human activities (3) exceeding applicable numeric temperature criteria values likely due natural background conditions, or (4) not assessed for temperature due to insufficient information. Second, DU classifications were combined with additional biological and landscape lines of evidence available to assess temperature-impairment and support of CWAL and SS beneficial uses at the AU spatial scale.

The framework and its outcomes are specific to stream temperature. Outcomes indicate whether stream temperature exceed numeric criteria due to human activities in the DU, and whether beneficial uses are impaired specifically by stream temperature. If the framework indicated stream temperatures are not due to human activities in the DU or stream temperature does not impair CWAL or SS beneficial uses, DEQ did not assume the framework applies equally to other pollutants or beneficial uses. For example, DEQ also collected *Escherichia coli* data at 33 locations in the Lochsa subbasin 2017-2019, and used Idaho

Water Body Assessment Guidance 3rd edition (DEQ 2016) protocols to evaluate whether contact recreation use was impaired. DEQ also independently evaluated available Lochsa Beneficial Use Reconnaissance Program (BURP) data, which is a generalized indicator of aquatic life use support and is not specific to temperature or a natural conditions indicator (Tetra Tech 2011, DEQ 2016). DEQ combined framework outcomes about temperature impairment with other assessment outcomes based on other readily available information assessed using standard protocols (DEQ 2016) to make final AU beneficial use support assessment decisions for the 2022 Integrated Report.

This pollutant-specific approach is consistent with the WQS, DEQ assessment guidance (DEQ 2016), and DEQ natural background provisions guidance (Mebane and Essig 2003). The WQS require evaluating "where natural background conditions exceed any applicable water quality criteria as determined by the Department" (IDAPA 58.01.02.054.04). DEQ considers "natural background conditions"—defined as the "physical, chemical, biological, or radiological conditions existing in a water body without human sources of pollution within the watershed" (IDAPA 58.01.02.10.63)—to be pollutant-specific (Mebane and Essig 2003). Thus, characterization of natural background conditions is necessary for each parameter evaluated in a natural conditions assessment (Mebane and Essig 2003). This framework (Figure 2) defines landscape criteria that indicate natural conditions relevant to temperature are present if met.

This assessment updates and replaces a previous Lochsa natural conditions assessment (Leinenbach 2005, supplemental materials S1). In contrast to the 2005 assessment, this assessment includes an analysis of stream temperature data, uses GRAIP-Lite modeling to estimate sediment delivery from roads, and includes an explicit analysis of anthropogenic stream shade loss rather than inferring shade lost based on riparian harvest records. In addition, whereas the 2005 assessment framework assigned an 'uncertain' natural conditions classification to nearly one third of Lochsa subwatersheds, this framework classified only 3 subwatersheds as needing further investigation (2 due to lack of temperature data, and one where the human factors affecting stream temperature needs further investigation).

In addition, this framework is conservative and protective of CWAL and SS beneficial uses for several reasons. First, our approach to assigning riparian shade impact scores (Figure 3) likely overestimated human impacts on shade for some DUs because it assumed shade deficits predicted by shade modeling only result from human activities. After excluding riparian areas exposed to recent wildfire from shade analysis, shade modeling still predicted shade deficits for some stream segments within wilderness where there are no known human disturbances (Figure 8). For stream segments near wildfire-impacted areas, predicted shade deficits may result from imperfect wildfire extent information. However, shade deficits were also predicted in some wilderness areas with little or no known wildfire impacts. This suggests some predicted shade deficits outside wilderness may reflect a combination of natural processes and human activities rather than only human activities. Shade model performance is described in detail in Supplemental Materials S4, and in general model performance was considered adequate for the intended application and conservative (protective). However, some DUs may have been assigned a 'potential impact' or 'likely impact' shade score when a lower shade score would more accurately reflect human impact levels.

Second, the forest harvest component of the framework (Figure 5) assumes forest harvest outside the riparian zone can have a measurable impact on stream temperatures if forest harvest levels are above designated "threshold" values. But whether or not harvest outside a riparian buffer has a temperature effect, and effect magnitude and duration depends on many factors (Moore et al. 2005, Sweeney and Newbold 2014). Thus, non-riparian harvest was conservatively assumed to result in measurable impacts to stream temperatures in the Lochsa at harvest levels above the reported thresholds.

Third, the roads component of the framework (Figure 4) used modeled stream sediment loading from roads to assign road impact scores. However, the relationship between sediment loading magnitude and temperature increase magnitude is not known. Sediment loading thresholds used to assign road impact scores were based on background sediment loading rates for forested areas in the literature. We conservatively assumed that any sediment loading increase above background would yield a measurable temperature increase, but to our knowledge empirical relationships between sediment loading increase and temperature increase have not been measured for forested watersheds.

Fourth, we assumed Idaho SS temperature criteria applied to all sites with temperature data (supplemental information S2). This is a protective approach because migration barriers and natural habitat characteristics such as stream slope, stream flow, and geology limit realized available spawning habitat. Therefore salmonid spawning may not actually be an existing use or possible in all stream segments with temperature data. For example, when delineating streams likely to serve as cold water refugia for bull trout and cutthroat trout during future climate change, Isaak et al. (2015) considered only reaches with slopes <15% and wetted width ≥ 1.0 m because trout are rare in small and steep streams. We did not apply such restrictions. Because we conservatively assumed that spawning is naturally possible everywhere in the Lochsa subbasin, but this is not likely the case, we likely overestimated the spatial extent of where SS criteria apply and where SS criteria value exceedances occur.

Available biological data suggest CWAL and SS beneficial uses are supported in DUs the framework classified as natural for temperature. Biological lines of evidence were not used when assessing natural temperature conditions at the DU scale because monitoring programs that generated available data were not designed as indicators of temperature impairment or natural conditions (see supplemental materials S3). However, biological data can be used to evaluate whether CWAL and SS beneficial uses are supported in DUs the framework classified as natural. If beneficial uses are supported in DUs classified as natural, this suggests these beneficial uses are not impaired by temperature and framework classifications may be protective of these uses.

Between 2016 and 2019, DEQ collected Beneficial Use Reconnaissance Program (BURP) data at 43 sites within the Lochsa subbasin (supplemental materials S3). BURP monitoring includes measurement of multiple stream physical (stream flow and channel characteristics), biological (macroinvertebrates, fish), and habitat measures and classifies sites as pass/fail, with a failing score suggesting CWAL use is not supported. BURP monitoring was designed as a generalized indicator of anthropogenic impacts, is not specific to temperature, and indicates consistency of general stream conditions with comparable least-disturbed reference sites rather than with natural temperature conditions (Tetra Tech 2011, DEQ 2016). Two of 43 2016-2019 BURP sites had a failing score. Both these sites were located within the Lower Big Sand Creek DU, which the framework independently classified as temperature-impaired due to a 'likely impact' shade score and a 'potential impact' other anthropogenic impacts score. The 2016-2019 BURP data indicated CWAL use was supported in all DUs classified as natural for temperature where BURP data were available. Across all BURP data collected 1995-2019, 137 of 147 BURP sites had a passing score, with all failing scores occurring only in DUs classified as temperature-impaired (34-Pete King

Creek, 10-Bimerick Creek, 12-Bald Mountain Creek, 29 –Imnamatnoon Creek, 15- Lower Brushy Fork, 42-Upper Brushy Fork, 40-Lower Big Sand Creek).

Multiple lines of evidence also indicate salmonid spawning occurs throughout the subbasin, including in DUs classified as natural for temperature. DEQ gathered data documenting the presence and distribution of young-of-the-year (age zero) salmonids within the Lochsa subbasin (supplemental materials S3). The presence of age zero salmonids in streams (< 5th order) suggests nearby spawning, and that salmonid spawning is an existing use within the stream (DEQ 2016). The presence of age 0 salmonids does not necessarily indicate salmonid spawning is at maximum or natural potential, but represents one line of evidence suggesting SS use is supported. There was documented evidence of salmonid spawning throughout the subbasin, and at least one data source documented spawning within each DU classified as natural. In addition, Chinook, Steelhead, and Bull Trout life history tables developed by a team of fisheries biologists in the *Lochsa Atlas Restoration Prioritization Framework* (Tetra Tech 2018) suggest salmonid spawning is widespread throughout all areas of the Lochsa subbasin, which prompted DEQ to assume SS is an existing use everywhere in the subbasin (supplemental materials S2).

Framework outcomes are also consistent with outcomes from two independent assessments. Out of 23 DUs classified as natural for temperature, 20 were within areas rated has having ‘excellent’ temperature conditions by the *Lochsa Atlas Restoration Prioritization Framework* (Tetra Tech 2018). The *Lochsa Atlas Restoration Prioritization Framework* divided the Lochsa subbasin into Biologically Significant Reaches (BSRs), defined as geographic areas “comprising stream reaches and associated upland watershed areas with similar fish use and limiting factor characteristics used to aid in determining priority restoration work areas” (Tetra Tech 2018). A team of fisheries, habitat restoration, and research biologists delineated BSRs and assigned each BSR a temperature score of ‘excellent’, ‘good’, ‘fair’, or ‘poor’ based on available stream temperature data and the Columbia River Inter-tribal Fish Commission Clearwater Basin temperature model, with ‘excellent’ scores indicating minimal potential for temperature improvement through restoration actions (Tetra Tech 2018). ‘Excellent’ scores in nearly all DUs as natural for temperature provide independent supporting evidence for framework outcomes. For the three DUs where the framework concluded natural background provisions for temperature were met, but *Lochsa Atlas Restoration Prioritization Framework* temperature scores were not excellent (Postoffice Creek, Deadman Creek, Glade Creek), differences resulted from different spatial scales between the two assessment approaches. BSRs are larger than DUs, and BSRs these DUs fell within also include additional DUs classified as temperature-impaired by this framework.

Framework outcomes are also consistent with US Forest Service (USFS) Watershed Condition Framework (WCF) outcomes (USFS 2011) based on most recent WCF data for the Lochsa (Andy Efta, USFS Regional Hydrologist, personal communication 8/30/2021). The WCF is the systematic approach USFS uses to classify HUC12 subwatersheds within USFS lands as either ‘Functioning Properly’, ‘Functioning at Risk’, or ‘Impaired Function’ for tracking watershed condition over time, and prioritizing watershed restoration efforts (USFS 2011). Watersheds classified as ‘Functioning Properly’ are those that “exhibit high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition” (USFS 2011). The WCF classifications are based on 12 lines of evidence, including riparian/wetland vegetation, roads, forest cover, aquatic biota and habitat, and water quality, and incorporate professional judgement of local USFS staff (USFS 2011). Twenty-two out of 23 DUs classified as natural for temperature were within HUC12 subwatersheds classified as ‘Functioning Properly’ by the WCF. The

WCF classified the Wendover Creek HUC12 (170603030304) as ‘Functioning at Risk’. USFS assigned this subwatershed ‘poor’ condition scores for water quality, fire effects, and rangeland vegetation lines of evidence, and ‘fair’ condition scores for roads, soils, and riparian/wetland vegetation lines of evidence. This framework divided this HUC12 into north and south segments, and classified the south segment as meeting natural conditions provisions for temperature, and the north segment as temperature-impaired. The seven other Lochsa HUC12 subwatersheds classified as ‘Functioning at Risk’ by the WCF were all classified as temperature-impaired by this framework.

This framework was developed for Idaho’s 2022 Integrated Report. EPA will review and approve or disapprove DEQ’s application of this framework to DEQ’s temperature impairment decisions for the Lochsa subbasin by issuing a decision on Idaho’s 2022 303(d) list. If EPA disapproves any assessment decisions resulting from the application of this framework, the CWA requires EPA to issue a revised 303(d) list for Idaho reflecting temperature impairment listings EPA considers appropriate. If DEQ applies this framework to the Lochsa subbasin in subsequent Integrated Report cycles, DEQ would incorporate new information as it becomes available, and EPA would also review and approve or disapprove subsequent applications through subsequent EPA 303(d) list approval decisions. This framework is specific to temperature and to the Lochsa subbasin, and cannot be applied to other parameters or subbasins without modification and justification. EPA would also review and approve or disapprove those applications through 303(d) list approval decisions.

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